Mandibular rotation and lower face height indicators

By Joseph Ghafari, DCD, DMD; Ilana Brin, DMD; and Mary Beth Kelley, DMD

Cephalometric evaluations of lower face height range from relating the mandibular corpus to cranial or facial references (sella-nasion, Frankfort plane, palatal plane), to comparing ratios of lower face height to upper or total face height.

Common representation of the lower border of the mandible consists of a line connecting menton to the most inferior and posterior portion of the mandibular body[1,2] or a line connecting gnathion to gonion[3]. Following implant studies by Bjork[4] and Bjork and Skieler[5],the utility of this representation has been questioned since considerable bone remodeling was found to occur with growth at the lower border of the mandibular body. This finding contradicts the earlier statements of Sicher and Weinman[6] that apposition of bone at the lower border of the mandible is negligible, but the relevance of this information is still unresolved.

The corpus axis (CA) has been proposed as an alternative to the mandibular plane by Ricketts et al[7]. This consists of a line connecting point Pm on the anterior contour of the chin to point Xi, a landmark constructed by bisecting the height and width of the ramus. Lower facial height is assessed using the angle ANS-Xi-Pm (Fig. 1). However, the Frankfort Horizontal defines the axes used in constructing point Xi, and the use of this horizontal may introduce clinically significant error because of variations in defining Porion and Orbitale[8,9]. Such an error may be propagated to affect the position of the dependent landmarks[10].

This paper evaluates mandibular rotation over a period of active growth and compares cephalometric methods used to evaluate the rotation. Specific aims are to compare the corpus axis with the mandibular plane in the assessment of mandibular rotation, and compare various measurements using corpus axis or the mandibular plane in the vertical assessment of the lower face. The ratio of lower face height to total face height is evaluated as a separate indicator of the facial vertical dimension.

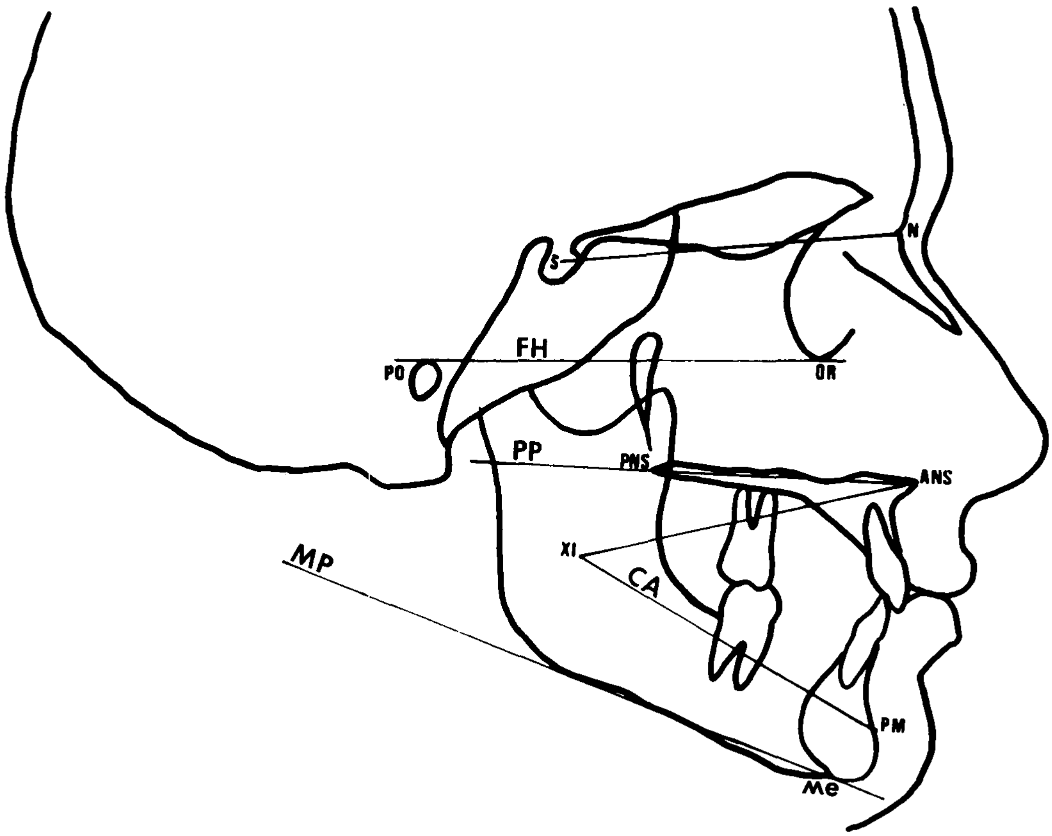
Abstract

Lower face height indicators and mandibular rotation are assessed at 7 and 12 years of age in a sample of 46 children, comparing the corpus axis and mandibular plane as indicators of change in mandibular position. The parameters involving the mandibular plane consistently show higher correlations.

Key Words

Cephalometrics • Lower face • Mandibular rotation • Vertical

Figure 1



Cephalometric landmarks and lines used: sella (S) nasion(N); NS line; porion (Po); orbitale (Or); Frankfort horizontal (FH); Xi (a constructed center of ramus, determined by geometric bisecting of the height and width of the ramus, using FH for orientation); supragonion or Pm, point at the anterior border of the symphysis between point B and pogonion, where the curvature changes from concave to convex; corpus axis CA connecting Xi and Pm; palatal plane PP connecting anterior (ANS) to posterior (PNS) nasal spines; mandibular plane MP as the tangent to the lower border through menton (Me); lower face height ANS-Me; upper face height N-ANS.

Materials and Methods

Lateral cephalographs of 46 white children (27 girls and 19 boys) from the Burlington study at the University of Toronto were evaluated at ages 7 (t_1) and 12 (t_2), based on the following criteria:

(1) A Class I occlusion in the early transitional dentition;

(2) No indication of caries affecting the mesial or distal surface of any teeth in the buccal segments;

(3) No missing teeth;

(4) No history of orthodontic treatment.

Each cephalograph was traced twice by each of two investigators and the means of the measured values calculated. Open-mouth cephalographs were used to supplement the details of sigmoid notch anatomy which is needed for exact determination of the corpus axis. The cephalometric landmarks and lines used are shown in Figure 1.

The sample was divided into forward rotators (FR) and backward rotators (BR), based on the direction of facial growth during observation period. This classification was made according to the S-N to CA angle and the S-N to MP angle. When the increment in each of these angles during the observation interval was positive, the pattern of rotation was considered BR. When the increment was negative, the rotation pattern was considered FR. The results based on the S-N to CA angle were then compared to the classification based on the S-N/MP angle.

Angular and linear measurements were made, recording angles ANS-Xi-Pm, FH/CA, FH/MP, PP/CA, and PP/MP; the distance ANS→Me and the ratio of lower face height to total face height (LFH/TFH). All values were measured at t_1 and t_2 and compared.

Interexaminer reliability was evaluated by calculating intraclass correlation coefficients for the various parameters studied. Correlation coefficient was calculated for the distribution of mandibular rotation in the FR and BR groups

Table 1
Intraclass correlation coefficients of measurements by two investigators at t_1 and t_2.

	t_1	t_2
SN/CA	0.70	0.60
SN/MP	0.96	0.96
FH/CA	0.61	0.67
FH/MP	0.93	0.87
PP/CA	0.73	0.74
PP/MP	0.94	0.96
ANS-Xi-PM	0.43	0.43
LFH(mm)	0.86	0.97
UFH(mm)	0.79	0.85

Table 2
Mandibular rotation as measured by the angles SN/MP and SN/CA. (FR = forward rotation; BR = backward rotation) Correlation coefficient r = 0.68.

		SN/MP FR	SN/MP BR	
SN/CA	FR	27	2	29
	BR	8	9	17
		35	11	46

Table 3.
Means and standard deviations of lower face indicators in FR groups established by the angles SN/MP and SN/CA.

	SN/MP t_1		SN/MP t_2	SN/CA t_1		SN/CA t_2
SN/CA	39.0 ± 4.8	**	37.7 ± 5.8	39.5 ± 5.0	*	37.5 ± 5.9
SN/MP	34.9 ± 4.7	*	32.2 ± 5.5	34.9 ± 4.6	*	32.1 ± 5.5
FH/CA	32.3 ± 4.4		31.5 ± 5.1	32.2 ± 4.4		31.5 ± 5.4
FH/MP	28.8 ± 4.4	*	25.9 ± 5.5	28.5 ± 4.1	**	25.9 ± 5.9
PP/CA	31.2 ± 4.3		30.1 ± 4.5	31.8 ± 4.5	*	30.2 ± 4.7
PP/MP	27.4 ± 4.2	*	24.3 ± 4.6	27.3 ± 4.2	*	24.5 ± 4.9
ANS-Xi-Pm	43.4 ± 3.4	**	42.4 ± 3.8	43.5 ± 3.6	**	42.4 ± 4.2
LFH/TFH (%)	0.57 ± 0.02	*	0.55 ± 0.02	0.57 ± 0.02	*	0.56 ± 0.0

*Statistically significant difference between measurements at t_1 and t_2: *$p<0.001$, **$p<0.01$.

according to SN/CA angle vs. SN/MP angle. A series of t-tests was conducted to compare, between t_1 and t_2, the lower face height indicators (S-N/CA, S-N/MP, FH/CA, FH/MP, PP/CA, PP/MP, ANS-Xi-PM, LFH/TFH) in the established FR and BR groups, and in the total sample without any group differentiation.

Results

Correlations between the measurements performed by the two investigators ranged from r = 0.43 to r = 0.97 (Table 1). All of the measurements which involved the corpus axis (FH/CA, PP/CA, S-N/CA, ANS-Xi-PM) showed a lower coefficient (r) than similar measurements which involved the mandibular plane (FH/MP, PP/MP, S-N/MP) or other parameters (LFH, UFH).

The distribution of FR and BR as established by S-N/MP or S-N/CA is shown in Table 2. Twenty-seven cases were FR and nine cases were BR as measured by both methods. The other ten cases were categorized differently by the two methods. The correlation of mandibular rotations based on S-N/MP and S-N/CA was r = 0.68.

Lower face height indicators are shown in Tables 3 and 4, following the classification of FR and BR according to S-N/CA and S-N/MP. Highly statistically significant differences ($p<0.001$) in the parameters measured at t_1 and t_2 were observed for the measurements involving MP in the FR groups (Table 2). The ratio LFH/TFH was also statistically significant in these groups ($p<0.001$).

In the BR groups, differences between t_1 and t_2 were statistically significant for S-N/MP in the BR group defined as such by S-N/MP, for S-N/CA in the group defined as BR by S-N/CA, and for the ratio LFH/TFH in both BR groups (defined by either S-N/MP or S-N/CA) (Table 4).

Since errors of classification of FR vs. BR may have resulted from small differences between these two groups, the values of the parameters were pooled and evaluated without any group differentiation. Statistically significant differences between t_1 and t_2 were then observed for all parameters not including CA (Table 5).

Table 4. Means and standard deviations of lower face indicators in BR groups established by the angles SN/MP and SN/CA.

	SN/MP			SN/CA		
	t_1		t_2	t_1		t_2
SN/CA	39.9 ± 7.0		40.7 ± 6.6	38.1 ± 5.9	*	40.0 ± 6.2
SN/MP	33.2 ± 7.2	*	35.2 ± 6.7	33.6 ± 6.6		34.3 ± 6.4
FH/CA	32.6 ± 5.7		32.8 ± 5.7	32.6 ± 5.2		32.4 ± 4.9
FH/MP	27.0 ± 6.0		27.4 ± 5.8	28.1 ± 6.0		26.8 ± 5.1
PP/CA	31.6 ± 6.0		32.3 ± 6.2	30.4 ± 4.9		31.3 ± 5.4
PP/MP	26.0 ± 5.7		26.7 ± 6.0	26.6 ± 5.3		25.6 ± 5.2
ANS-Xi-Pm	43.9 ± 4.4		44.2 ± 5.4	43.6 ± 3.9		43.6 ± 4.3
LFH/TFH	0.57 ± 0.02	*	0.56 ± 0.02	0.57 ± 0.02	*	0.56 ± 0.0

*Statistically significant difference between measurements at t_1 and t_2: $p<0.001$

Discussion

Changes in the lower face have been studied with various methods. The present investigation looked at parameters of evaluation of the lower face as it related to the maxilla (PP/CA, PP/MP, ANS-Xi-PM, LFH/TFH), the Frankfort horizontal (FH/CA, FH/MP), and to the cranial base (S-N/CA, S-N/MP).

When the measurements of the two examiners were compared, the parameters involving MP consistently showed higher correlation than those related to CA (Table 1). This finding suggests that the construction of CA is subject to more error than that of the mandibular plane MP. Indeed, the construction of point Xi involves bisecting the height and width of the ramus with lines based on Frankfort horizontal, all subject to error of estimation and/or location of landmarks (e.g. Orbitale, Porion). Also, the location of point Pm may involve some variation.

However, these findings do not necessarily mean that MP is more reliable than CA in representing the mandibular body.

Discrepancies in determining mandibular rotation occurred in ten cases (Table 2). These differences may be due to the errors inherent in the construction of CA and MP, and/or changes of landmarks S and N relative to each other.

Statistical significance between t_1 and t_2 for angular lower face height indicators was observed distinctly for those involving MP in the FR groups (Table 3). This finding underlines a difference, *which may not necessarily be clinically relevant*, between MP and CA. However, in the BR groups, S-N/MP and S-N/CA were the only angular parameters with a statistically significant difference between t_1 and t_2, and only in the BR group defined as such by either S-N/MP or S-N/CA, respectively (Table 4).

This result reflects the small differences between t_1 and t_2, and suggests possible misinterpretations of lower face height if based solely on either S-N/MP or S-N/CA. Differences may also have resulted from the size of the sample in each group. While 27 of the 46 cases studied were defined as FR by either S-N/MP or S-N/CA, only 9 of the 46 were identified as BR by both criteria.

When the sample was not differentiated into FR and BR groups, the mean values between t_1 and t_2 tended to be smaller, reflecting the prevalence of forward rotation in the total sample (Table 5). Also, statistically significant differences between t_1 and t_2 were observed for all parameters not measuring CA, regardless of the reference plane (S-N,FH,PP). This result suggests that either CA was not accurately reproducible, or that MP undergoes significant remodeling between t_1 and t_2. Each possibility corroborates criticism addressed at the reliability of CA or MP[4,10].

A larger sample including and differentiating more extreme rotation patterns is needed to form a conclusion on this question. Nevertheless, caution is indicated when evaluating lower face height. A comparison of measurements including MP and CA is suggested for such evaluation.

Moreover, mandibular rotation over time may be more accurately evaluated following superposition of cephalometric tracings on structures of the cranial and maxillary bases. Indeed, assessing mandibular rotation through angular measurements (S-N/MP, PP/MP, etc.) does not take into account remodeling changes within the anterior cranial baase or the maxillary base.[11,12]

Since measurements of the ratio LFH/TFH were consistently significant ($p<0.001$) in FR and BR groups regardless of the method of classification (Tables 3 and 4), and in the total sample (Table 5), this study supports the use of this ratio as an indicator of anterior lower face height.

However, the differences between the means of the ratios in FR and BR groups are so small (1% to 2%) that they may not be clinically significant. This suggests the possibility of backward or forward rotation of a mandible while the ratio of anterior LFH/TFH remains unchanged. Consequently, this ratio should not be used as an indicator of mandibular rotation in the individual case.

Finally, no specific conclusion may be formed from this investigation regarding the contribution of the palatal plane in the vertical assessment of the lower face. The angle PP/MP does describe vertical patterns of "divergency"; however, a vertical pattern defined within normal range by angle S-N/MP or FH/MP may be classified as "hyperdivergent" by the PP/MP angle if the palatal plane is tipped by a relatively low PNS and high ANS. Since the sample studied did not include extreme (especially backward) rotating patterns, the findings may reflect some importance of PP/MP measurements in those patterns particularly.

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ANS-Xi-Pm	43.6 ± 3.6		42.8 ± 4.2
LFH/TFH (%)	0.57 ± 0.02	*	0.56 ± 0.02

*Statistically significant difference between measurements at t_1 and t_2: $p<0.001$.

Table 5. Combined values of lower face indicators, without differentiation in FR and BR groups, at times t_1 and t_2.

Author Address:
Joseph Ghafari, DCD, DMD
Department of Orthodontics
School of Dental Medicine
University of Pennsylvania
4001 Spruce Street A1
Philadelphia, PA 19104

Dr. Ghafari is Associate Professor of Orthodontics at the University of Pennsylvania, School of Dental Medicine. He holds the degree of Docteur en Chirurgie Dentaire from the Université Saint Joseph, Beirut, Lebanon and a DMD degree from the University of Pennsylvania, and a Certificate in Orthodontics from the Harvard School of Dental Medicine, Forsyth Dental Center, Boston, Massachusetts.

Dr. Brin is a member of the Faculty of Orthodontics at the Hebrew University, Hadassah School of Dental Medicine, Jerusalem, Israel. She holds a DMD degree from the Hebrew University and a Certificate in Orthodontics from the University of Pennsylvania School of Dental Medicine.

Dr. Kelley is in the private practice of Orthodontics in Narberth, Pennsylvania in the Philadelphia area. She holds a DMD degree from Tufts University in Boston, and a Certificate in Orthodontics from the University of Pennsylvania School of Dental Medicine.

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